Volunteer Army Ammunition Plant
Chattanooga
Hamilton County
Tennessee

HAER No. TN-8

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Department of the Interior
Washington, DC 20013-7127

HISTORIC AMERICAN ENGINEERING RECORD

Volunteer Army Ammunition Plant

TN-8

Location:	In Hamilton County Tennessee, northeast of Chattanoga.
Date of Construction:	Established in 1941.
Owner:	Department of the Army
Significance:	Volunteer Army Ammunition Plant was established during World War II to produce TNT. Following periods of law-away, the plant was reactivated for the Korean and Vietnam Wars.
Historical Report Prepared by:	Peter Rathbun, 1984.
Prepared for Transmittal by:	Robie S. Lange, HABS/HAER, 1985.

EXECUTIVE SUMMARY

Volunteer Army Ammunition Plant (VAAP) is a government-owned, contractor-operated (GOCO) munitions plant situated on 7,353 acres northeast of Chattanooga, Tennessee. The installation is part of the Army's Armament, Munitions and Chemical Command (AMCCOM). Constructed in 1941-1943 to produce trinitrotoluene (TNT), VAAP remained in operation from July 1942 to August 1945. The installation was reactivated for the Korean War and remained in production until 1957, when placed on standby status. Rehabilitation for the Vietnam War began in 1966 and full production resumed. Major modernization, including construction of continuous-process TNT lines and a new acid plant, began in 1971 and was completed before the plant was laid away in 1977.

The installation currently consists of 422 buildings, nearly two-thirds of which date from the World War II period. Most of the buildings are utilitarian in nature. Current production facilities include examples of both modern and World War II technology. There are no Category I or II Historic Properties at VAAP. The Redwater Treatment Plant (Buildings 816, 816-1, 816-2) is a Category III Historic Property because it is a good example of early munitions-related pollution abatement efforts.

CONTENTS

PREFACE

This report presents the results of an historic properties survey of the Volunteer Army Ammunition Plant (VAAP). Prepared for the United States Army Materiel Development and Readiness Command (DARCOM), the report is intended to assist the Army in bringing this installation into compliance with the National Historic Preservation Act of 1966 and its amendments, and related federal laws and regulations. To this end, the report focuses on the identification, evaluation, documentation, nomination, and preservation of historic properties at the Volunteer AAP. Chapter 1 sets forth the survey's scope and methodology; Chapter 2 presents an architectural, historical, and technological overview of the installation and its properties; and Chapter 3 identifies significant properties by Army category and sets forth preservation recommendations. Illustrations and an annotated bibliography supplement the text.

This report is part of a program initiated through a memorandum of agreement between the National Park Service, Department of the Interior, and the U.S. Department of the Army. The program covers 74 DARCOM installations and has two components: 1) a survey of historic properties (districts, buildings, structures, and objects), and 2) the development of archaeological overviews. Stanley H. Fried, Chief, Real Estate Branch of Headquarters DARCOM, directed the program for the Army, and Dr. Robert J. Kapsch, Chief of the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) directed the program for the National Park Service. Sally Kress Tompkins was program manager, and Robie S. Lange was

project manager for the historic properties survey. Technical assistance was provided by Donald C. Jackson.

Building Technology Incorporated acted as primary contractor to HABS/HAER for the historic properties survey. William A. Brenner was BTI's principal-in-charge and Dr. Larry D. Lankton was the chief technical consultant. Major subcontractors were the MacDonald and Mack Partnership and Jeffrey A. Hess. The author of this report was Peter Rathbun. The author gratefully acknowledges the administrative assistance of Commanding Officer's Representative James E. Fry and the on-site guidance of Richard Twitchell, Sarah Hammond, and John Millard, of ICI Americas, Inc.

The complete HABS/HAER documentation for this installation will be included in the HABS/HAER collections at the Library of Congress, Prints and Photographs Division, under the designation HAER No. TN-8.

Chapter 1

INTRODUCTION

SCOPE

This report is based on an historic properties survey conducted in September 1983 of all Army-owned properties located within the official boundaries of the Volunteer Army Ammunition Plant (VAAP). The survey included the following tasks:

- Completion of documentary research on the history of the installation and its properties.

- Completion of a field inventory of all properties at the installation.

- Preparation of a combined architectural, historical, and technological overview for the installation.

- Evaluation of historic properties and development of recommendations for preservation of these properties.

Also completed as a part of the historic properties survey of the installation, but not included in this report, are HABS/HAER Inventory cards for 26 individual properties. These cards, which constitute HABS/HAER Documentation Level IV, will be provided to the Department of the Army. Archival copies of the cards, with their accompanying photographic

negatives, will be transmitted to the HABS/HAER collections at the Library of Congress.

The methodology used to complete these tasks is described in the following section of this report.

METHODOLOGY

1. Documentary Research

The VAAP was one of a series of government-owned TNT plants constructed during 1941-1943. Because it was part of an extensive manufacturing network, an evaluation of its historical and technological significance requires a general understanding of the wartime munitions industry. To identify published documentary sources on the American munitions industry during World War II and the Korean and Vietnam wars, research was conducted in standard bibliographies of military history, engineering, and the applied sciences. Unpublished sources were identified by researching the historical and technical archives of the U.S. Army Armament, Munitions, and Chemical Command (AMCCOM) at Rock Island Arsenal.[1]

In addition to this general research, a concerted effort was made to locate published and unpublished material dealing specifically with the history and technology of the VAAP. This site-specific research was conducted primarily at the AMCCOM Historical Office at Rock Island

Arsenal, the Chattanooga Public Library, and the government and contractor files at the VAAP. The Tennessee State Historic Preservation Officer also was contacted but provided no additional information.

On the basis of this literature search, a number of valuable sources were identified. These included general information about the wartime munitions industry and the manufacture of explosives, and an unpublished detailed account of the construction at VAAP.

Army records used for the field inventory included current Real Property Inventory (RPI) printouts that listed all officially recorded buildings and structures by facility classification and date of construction; the installation's property record cards; base maps and photographs supplied by installation personnel; and installation master planning, archaeological, environmental assessment, and related reports and documents. A complete listing of this documentary material may be found in the bibliography.

2. Field Inventory

The field inventory was conducted in September 1983 by Robert Mack and Peter Rathbun. James Fry provided administrative assistance; Richard Twitchell, Sarah Hammond, and John Millard provided research assistance and guided the on-site inspections.

Field inventory procedures were based on the HABS/HAER Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures.[2] All areas and properties were visually surveyed. Building locations and approximate dates of construction were noted from the installation's property records and field-verified. Interior surveys were made of the major facilities to permit adequate evaluation of architectural features, building technology, and production equipment.

Field inventory forms were prepared for, and black and white 35 mm photographs taken of all buildings and structures through 1945 except basic utilitarian structures of no architectural, historical, or technological interest. When groups of similar ("prototypical") buildings were found, one field form was normally prepared to represent all buildings of that type. Field inventory forms were also completed for representative post-1945 buildings and structures.[3] Information collected on the field forms was later evaluated, condensed, and transferred to HABS/HAER Inventory cards.

3. Historical Overview

A combined architectural, historical, and technological overview was prepared from information developed from the documentary research and the field inventory. It was written in two parts: 1) an introductory description of the installation, and 2) a history of the installation

by periods of development, beginning with pre-military land uses. Maps and photographs were selected to supplement the text as appropriate.

The objectives of the overview were to 1) establish the periods of major construction at the installation, 2) identify important events and individuals associated with specific historic properties, 3) describe patterns and locations of historic property types, and 4) analyze specific building and industrial technologies employed at the installation.

4. Property Evaluation and Preservation Measures

Based on information developed in the historical overviews, properties were first evaluated for historical significance in accordance with the eligibility criteria for nomination to the National Register of Historic Places. These criteria require that eligible properties possess integrity of location, design, setting, materials, workmanship, feeling, and association, and that they meet one or more of the following:[4]

A. Are associated with events that have made a significant contribution to the broad patterns of our history.

B. Are associated with the lives of persons significant in the nation's past.

C. Embody the distinctive characteristics of a type, period, or method of construction, represent the work of a master, possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction.

D. Have yielded, or may be likely to yield, information important in pre-history or history.

Properties thus evaluated were further assessed for placement in one of five Army historic property categories as described in Army Regulation 420-40:[5]

Category I	Properties of major importance
Category II	Properties of importance
Category III	Properties of minor importance
Category IV	Properties of little or no importance
Category V	Properties detrimental to the significance of adjacent historic properties.

Based on an extensive review of the architectural, historical, and technological resources identified on DARCOM installations nationwide,

four criteria were developed to help determine the appropriate categorization level for each Army property. These criteria were used to assess the importance not only of properties of traditional historical interest, but also of the vast number of standardized or prototypical buildings, structures and production processes that were built and put into service during World War II, as well as of properties associated with many post-war technological achievements. The four criteria were often used in combination and are as follows:

1) Degree of importance as a work of architectural, engineering, or industrial design. This criterion took into account the qualitative factors by which design is normally judged: artistic merit, workmanship, appropriate use of materials, and functionality.

2) Degree of rarity as a remaining example of a once widely used architectural, engineering, or industrial design or process. This criterion was applied primarily to the many standardized or prototypical DARCOM buildings, structures, or industrial processes. The more widespread or influential the design or process, the greater the importance of the remaining examples of the design or process was considered to be. This criterion was also used for non-military structures such as farmhouses and other once prevalent building types.

3) Degree of integrity or completeness. This criterion compared the current condition, appearance, and function of a building, structure, architectural assemblage, or industrial process to its original or most historically important condition, appearance, and function. Those properties that were highly intact were generally considered of greater importance than those that were not.

4) Degree of association with an important person, program, or event. This criterion was used to examine the relationship of a property to a famous personage, wartime project, or similar factor that lent the property special importance.

The majority of DARCOM properties were built just prior to or during World War II, and special attention was given to their evaluation. Those that still remain do not often possess individual importance, but collectively they represent the remnants of a vast construction undertaking whose architectural, historical, and technological importance needed to be assessed before their numbers diminished further. This assessment centered on an extensive review of the military construction of the 1940-1945 period, and its contribution to the history of World War II and the post-war Army landscape.

Because technology has advanced so rapidly since the war, post-World War II properties were also given attention. These properties were evaluated in terms of the nation's more recent accomplishments in weaponry, rocketry, electronics, and related technological and scientific endeavors. Thus the traditional definition of "historic" as a property 50 or more years old was not germane in the assessment of either World War II or post-war DARCOM buildings and structures; rather, the historic importance of all properties was evaluated as completely as possible regardless of age.

Property designations by category are expected to be useful for approximately ten years, after which all categorizations should be reviewed and updated.

Following this categorization procedure, Category I, II, and III historic properties were analyzed in terms of:

- Current structural condition and state of repair. This information was taken from the field inventory forms and photographs, and was often supplemented by rechecking with facilities engineering personnel.

- The nature of possible future adverse impacts to the property. This information was gathered from the installation's master planning documents and rechecked with facilities engineering personnel.

Based on the above considerations, the general preservation recommendations presented in Chapter 3 for Category I, II, and III historic properties were developed. Special preservation recommendations were created for individual properties as circumstances required.

5. Report Review

Prior to being completed in final form, this report was subjected to an in-house review by Building Technology Incorporated. It was then sent in draft to the subject installation for comment and clearance and, with its associated historical materials, to HABS/HAER staff for technical review. When the installation cleared the report, additional draft copies were sent to DARCOM, the appropriate State Historic Preservation Officer, and, when requested, to the archaeological contractor performing parallel work at the installation. The report was revised based on all comments collected, then published in final form.

NOTES

1. The following bibliographies of published sources were consulted: Industrial Arts Index, 1938-1957; Applied Science and Technology Index, 1958-1980; Engineering Index, 1938-1983; Robin Higham, ed., A Guide to the Sources of United States Military History (Hamden, Conn.: Archon Books, 1975); John E. Jessup and Robert W. Coakley, A Guide to the Study and Use of Military History (Washington, D.C.: U.S. Government Printing Office, 1979); "Military Installations," Public Works History in the United States, eds., Suellen M. Hoy and Michael C. Robinson (Nashville: American Association for State and Local History, 1982), pp. 380-400. AMCCOM (formerly ARRCOM, or U.S. Army

Armament Materiel Readiness Command) is the military agency responsible for supervising the operation of government-owned munititions plants; its headquarters are located at Rock Island Arsenal, Rock Island, Illinois. Although there is no comprehensive index to AMCCOM archival holdings, the agency's microfiche collection of unpublished reports is itemized in ARRCOM, Catalog of Common Sources, Fiscal Year 1983, 2 vols. (no pl.: Historical Office, ARRCOM, Rock Island Arsenal, n.d.).

2. Historic American Buildings Survey/Historic American Engineering Record, National Park Service, Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures (unpublished draft, 1982).

3. Representative post-World War II buildings and structures were defined as properties that were: (a) "representative" by virtue of construction type, architectural type, function, or a combination of these, (b) of obvious Category I, II, or III historic importance, or (c) prominent on the installation by virtue of size, location, or other distinctive feature.

4. National Park Service, How to Complete National Register Forms (Washington, D.C.: U.S. Government Printing Office, January 1977).

5. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).

Chapter 2

HISTORICAL OVERVIEW

BACKGROUND

Volunteer Army Ammunition Plant (VAAP) is a government-owned, contractor-operated munitions plant situated on 7,312 acres northeast of Chattanooga, Tennessee. Constructed in 1941-1943 to produce trinitrotoluene (TNT), VAAP remained in operation from July 1942 to August 1945. It was reactivated in 1952 for the Korean War and remained in production until 1957, when placed on standby status. Rehabilitation began in early 1966 and production in support of the Vietnam War was resumed in March 1966. Major modernization began in 1971 and was completed before the plant was laid away in 1977.[1]

Of the 422 buldings at VAAP, 281 remain from the original construction period (Figures 1 and 2).[2] Today approximately one-third of the buildings are used for manufacturing, approximately one-half for storage, and the remainder for administration, maintenance, and utilities; these proportions have not changed significantly since World War II.[3] Current production facilities include examples of both modern and World War II technology.

For a more detailed understanding of the plant's architectural and technological history, it is necessary to look more closely at the site's three

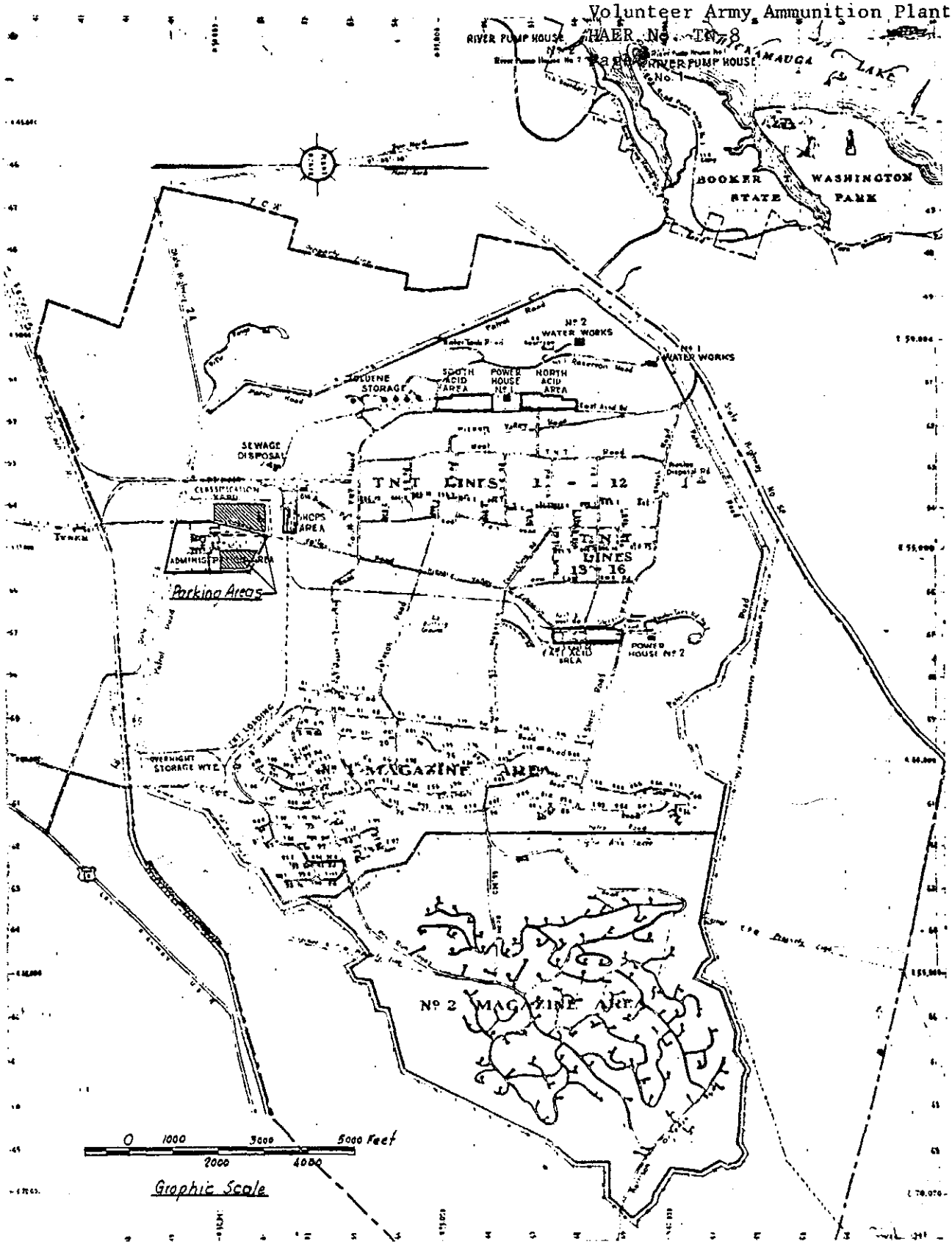

Figure 1: Volunteer Army Ammunition Plant (VAAP). Site plan, 1943. (Source: ICI Americas, Inc., VAAP.)

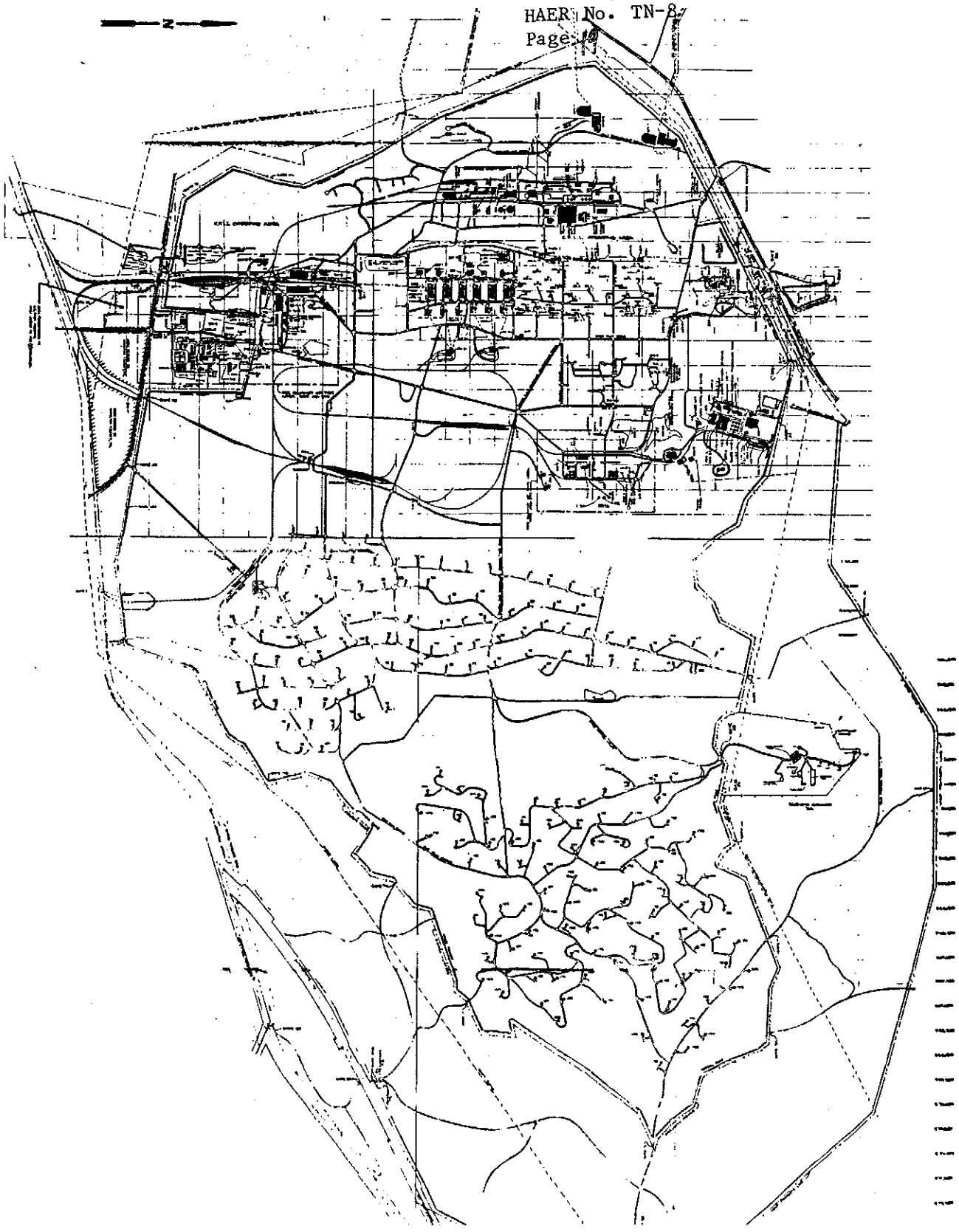

Figure 2: VAAP. Current site plan. (Source: ICI Americas, Inc., VAAP.)

major production periods: World War II, the Korean War, and the Vietnam War.

WORLD WAR II

In 1939, when the United States was faced with possible involvement in the war in Europe, its munitions production capability was extremely low. Although a few small plants manufactured explosives, the quantity of TNT being produced was far below the amount required for a modern war. In addition, other types of plants could not be converted to TNT production because of the specialized nature of the manufacturing process. To deal with this problem, the Army Ordnance Department developed a unique entity -- a system of ammunition plants owned by the government but operated by civilian contractors.[4] Authorized on August 1, 1941, VAAP was one of the plants constructed during the second phase of World War II munitions plant construction.

Site Selection and Former Land Use

The site selected for VAAP conformed to the basic criteria for World-War-II high explosives plants. These criteria included:

1) a location at least 200 miles from the coasts or international borders as a protection against enemy bombardment
2) ample supplies of raw materials
3) a suitable labor supply

4) large tracts of available land to allow adequate separation of facilities, to accommodate buffer areas, and to provide room for expansion
5) access to main highway and rail facilities
6) adequate electrical power
7) ample water for processing
8) proximity to ordnance plants requiring TNT
9) potential for rapid plant construction.[5]

Beginning in late summer of 1941 the government purchased 8,508 acres for the plant.[6] Most of the land had been used for agricultural purposes; there also were two small residential clusters, seven cemeteries, and one church on the site. The cemeteries have been retained, but none of the buildings.[7]

Construction

On August 1, 1941, the Army Ordnance Department entered a contract with Stone and Webster Engineering Corporation of New York City for the design and construction of VAAP.[8] Stone and Webster already was familiar with ordnance construction, because the firm was just finishing Kankakee Ordnance Works.[9]

Prior to construction, the Ordnance Department designated Hercules Powder Company of Wilmington, Delaware, as operating contractor. Hercules, already involved in the development of the Radford Ordnance Works, was also

experienced in ordnance construction. At VAAP, Hercules provided architectural and engineering services, including construction inspection, for the manufacturing structures and equipment.[10]

Work at the site began on October 6, 1941, and by July 1942 TNT Lines 1 and 2 were running at capacity. Original plans called for twelve TNT lines, two sets of acid production and concentration facilities, and associated storage and support facilities. In May 1942 the plans were revised to include four additional TNT lines, a third acid facility, and additional storage and support facilities.[11]

When completed in June 1943, VAAP consisted of 433 buildings. Most, other than storage magazines, were located in a low, flat area along the western third of the site. The TNT lines were roughly centered in this area, with the three acid facilities flanking them (Figure 3). Utilities also were sited on the periphery of the manufacturing area, with power plants to the north and west, the water works to the west, and waste treatment facilities to the north. Shop and administrative areas lay to the south.[12]

Explosives storage areas were located to the east of the plant on rolling land not suited to manufacturing. Original plans called for 100 barrel-vaulted "igloos" (Buildings 901-1 through 901-100) to be constructed in conformance with standard Army ordnance plans (Figure 4).[13] As a result of plant expansion, a second set of 100 magazines (Buildings 901-101 through 901-200) was constructed using the Corbetta or "beehive" design (Figure 5).[14]

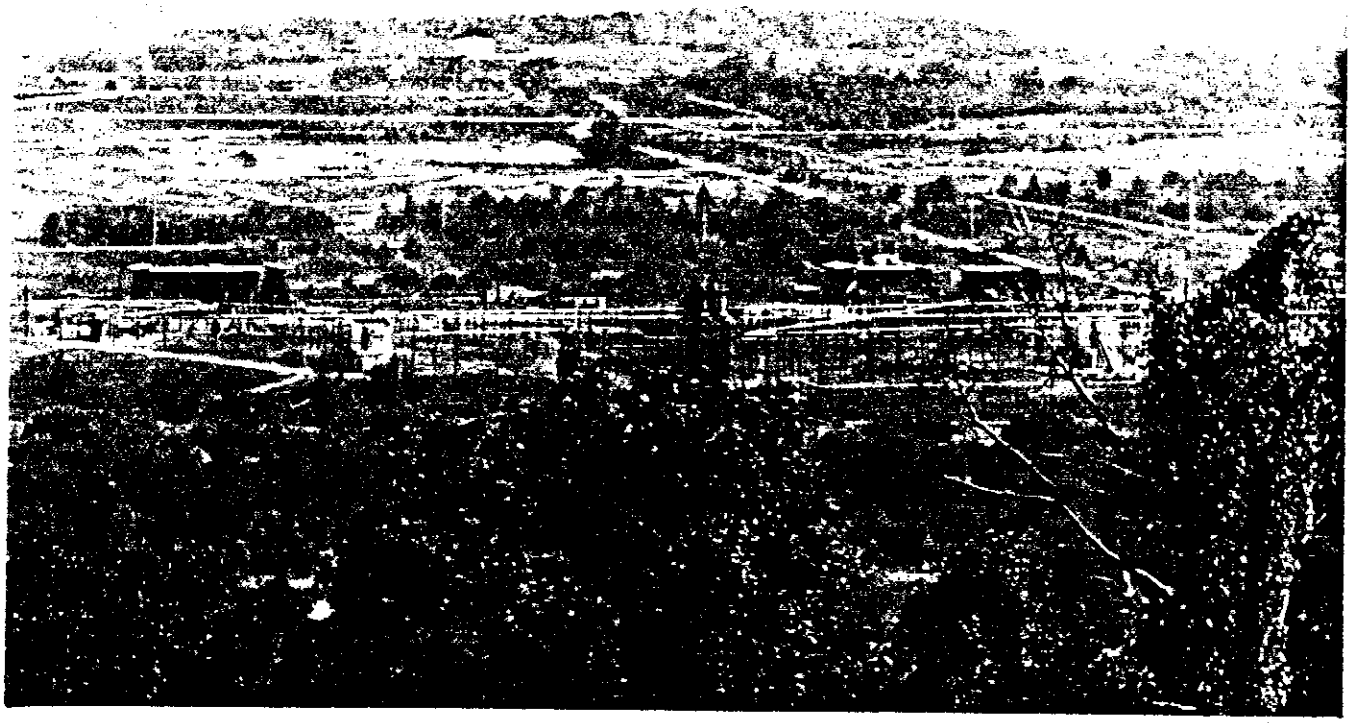

Figure 3: Two TNT batch lines extending from (A) Mono-House through (B) Wash House. (Source: Field inventory photograph, 1983, Peter Rathbun, MacDonald and Mack Partnership.)

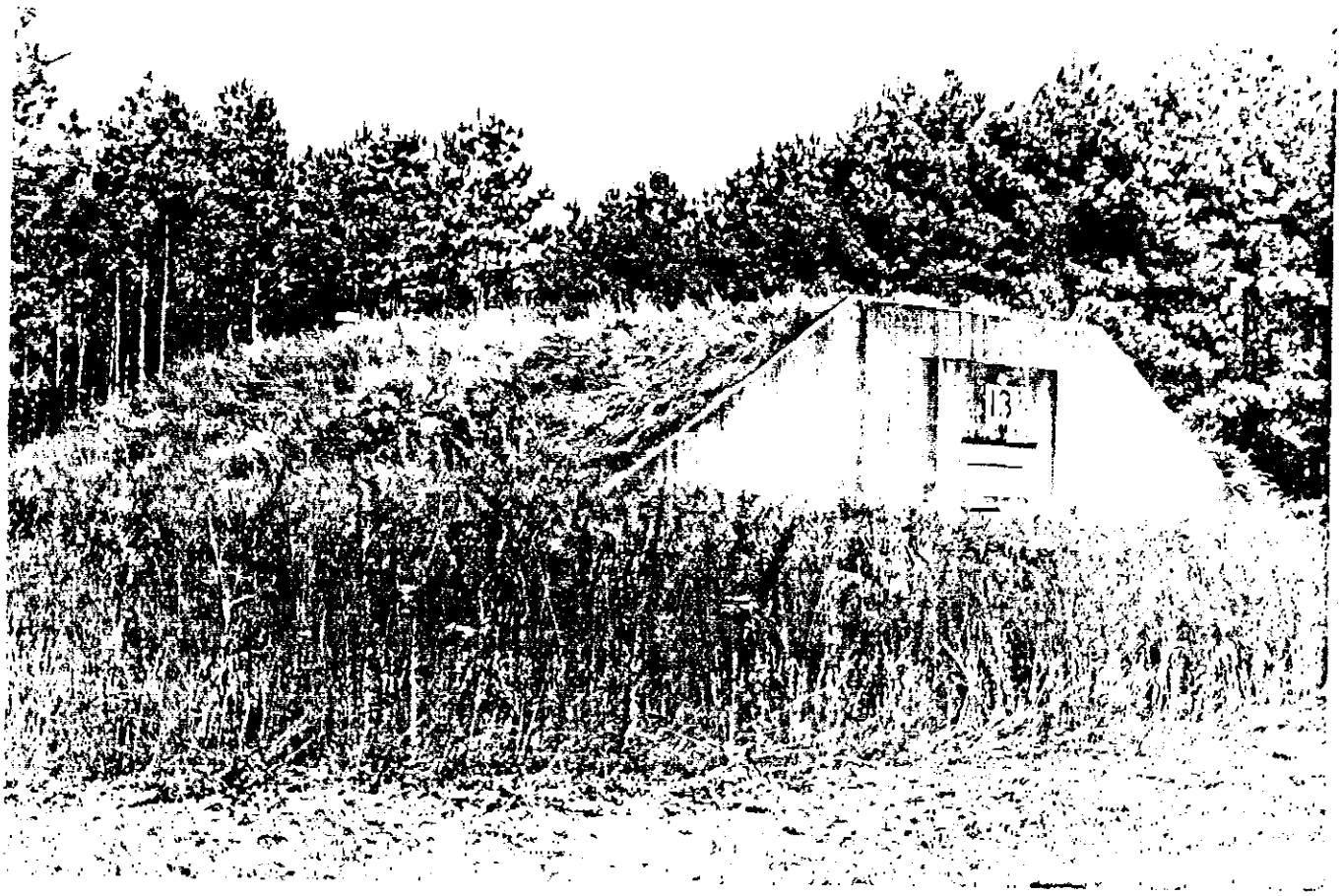

Figure 4: Barrel-vaulted Igloo (Building 901-13). (Source: Field inventory photograph, 1983, Peter Rathbun, MacDonald and Mack Partnership.)

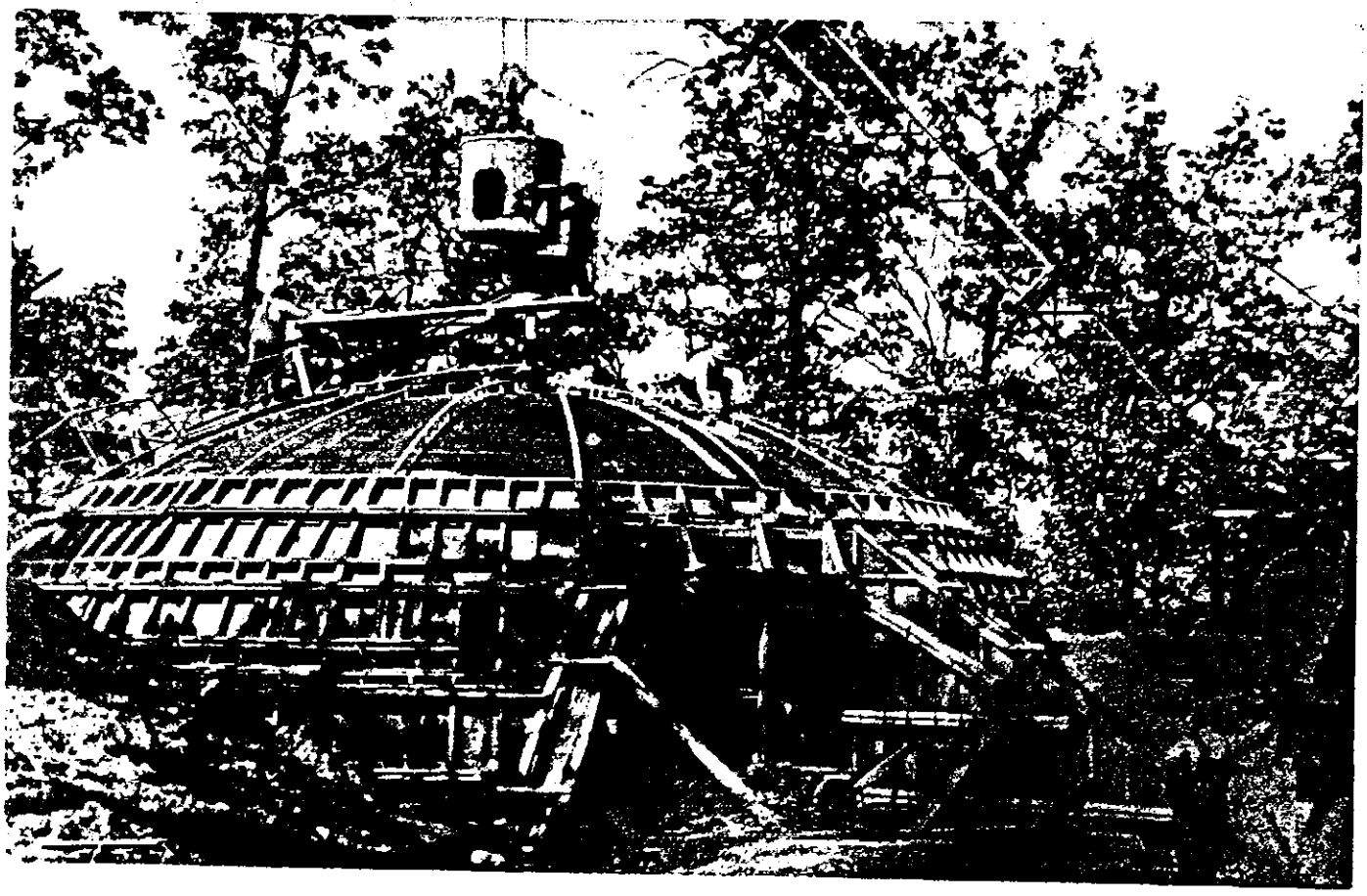

Figure 5: Corbetta Beehive Magazine under construction.
(Source: "Completion Report.")

Layout and design of the plant was intended to prevent propagation of accidental fires or explosions. Each step of the TNT manufacturing process took place in a separate building, with substantial spacing between buildings. Those buildings most susceptible to fire or explosion, such as the Bi- and Tri-nitration Houses (802-series Buildings, currently designated as the Tri-nitration Houses), were raised off the ground so that the mix could be dumped into a tank of water in an emergency. In addition, earth-filled barricades surrounded these buildings to absorb and deflect any blast (Figure 6). Escape chutes on all buildings permitted rapid egress from upper floors (Figure 7).[15]

Shortages of steel and other materials affected the design of the buildings at VAAP. Nearly all the manufacturing and support buildings were constructed with wood framing, flooring, and siding. Wood members subject to chemical attack were covered with lead. The notable exceptions to wood construction were the power plants, which were constructed with steel frames (Figure 8).[16]

Technology

Hercules Powder Company took control of TNT Lines 1 and 2 on July 15, 1942, and began production soon after. Production continued until August 1945, yielding over 800 million tons of TNT.[17] During that time VAAP produced not only TNT but also several of the raw materials required for its manufacture.

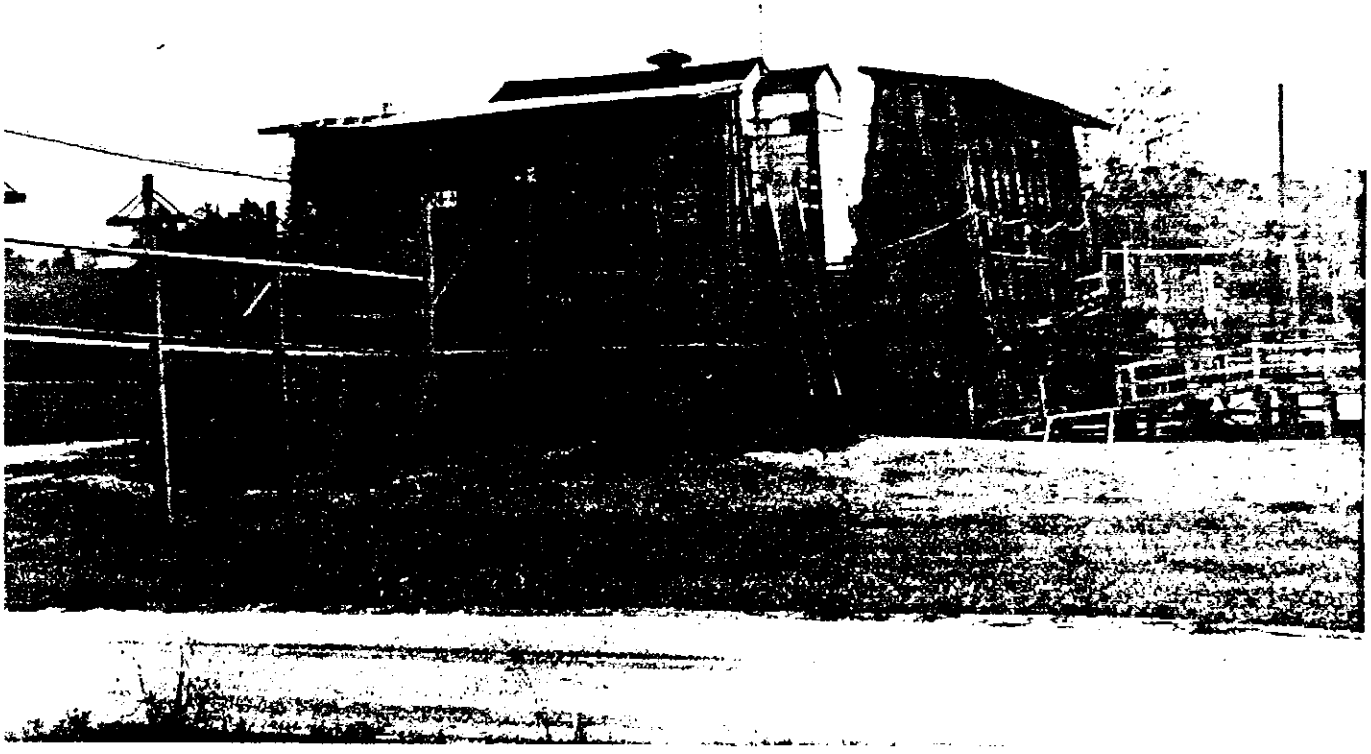

Figure 6: TNT Wash House (Building 806-4) surrounded by barricades. (Source: Field inventory photograph, Peter Rathbun, MacDonald and Mack Partnership.)

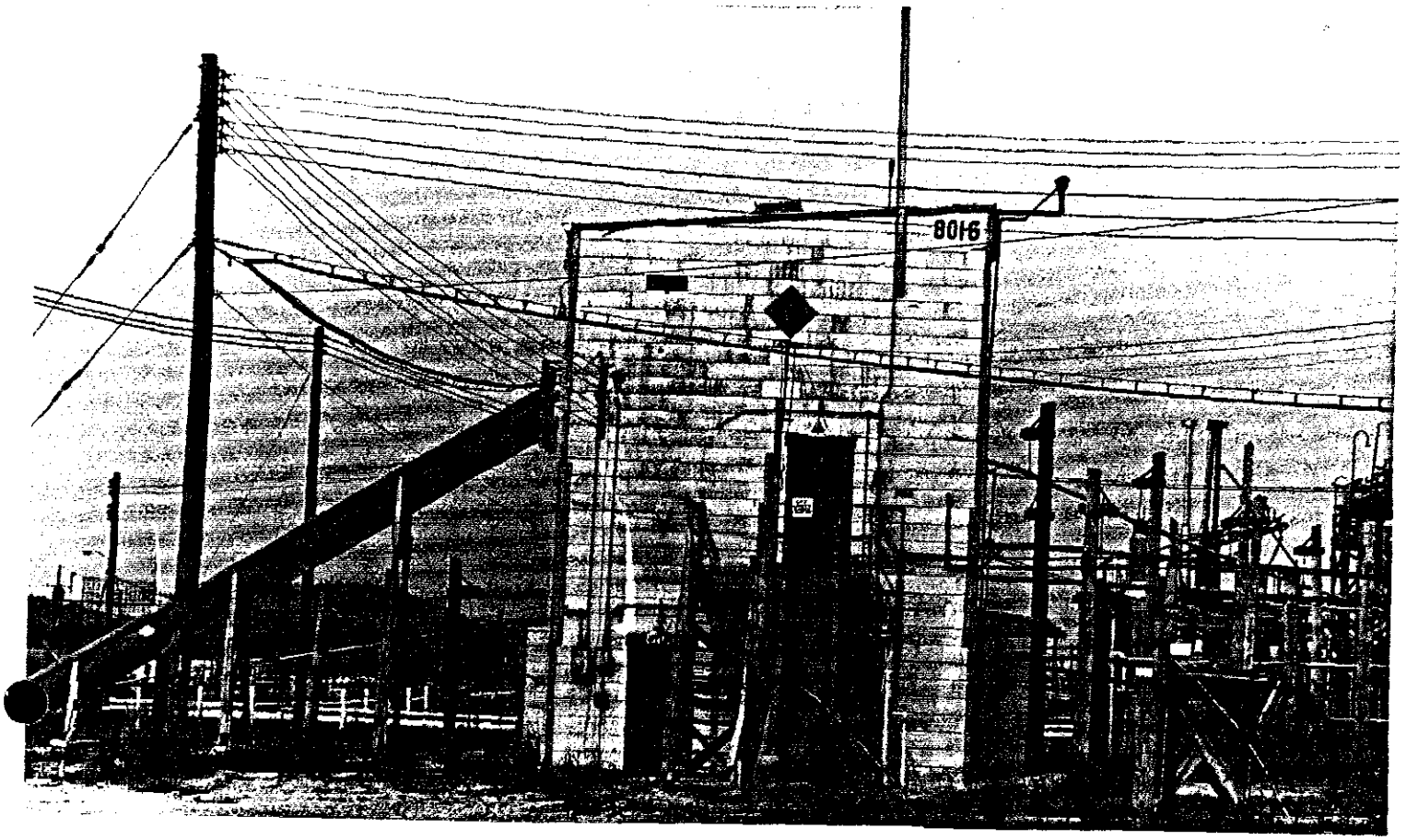

Figure 7: Mono-House (Building 801-6) with safety chutes. (Source: Richard Twitchell, ICI Americas, Inc., 1983.)

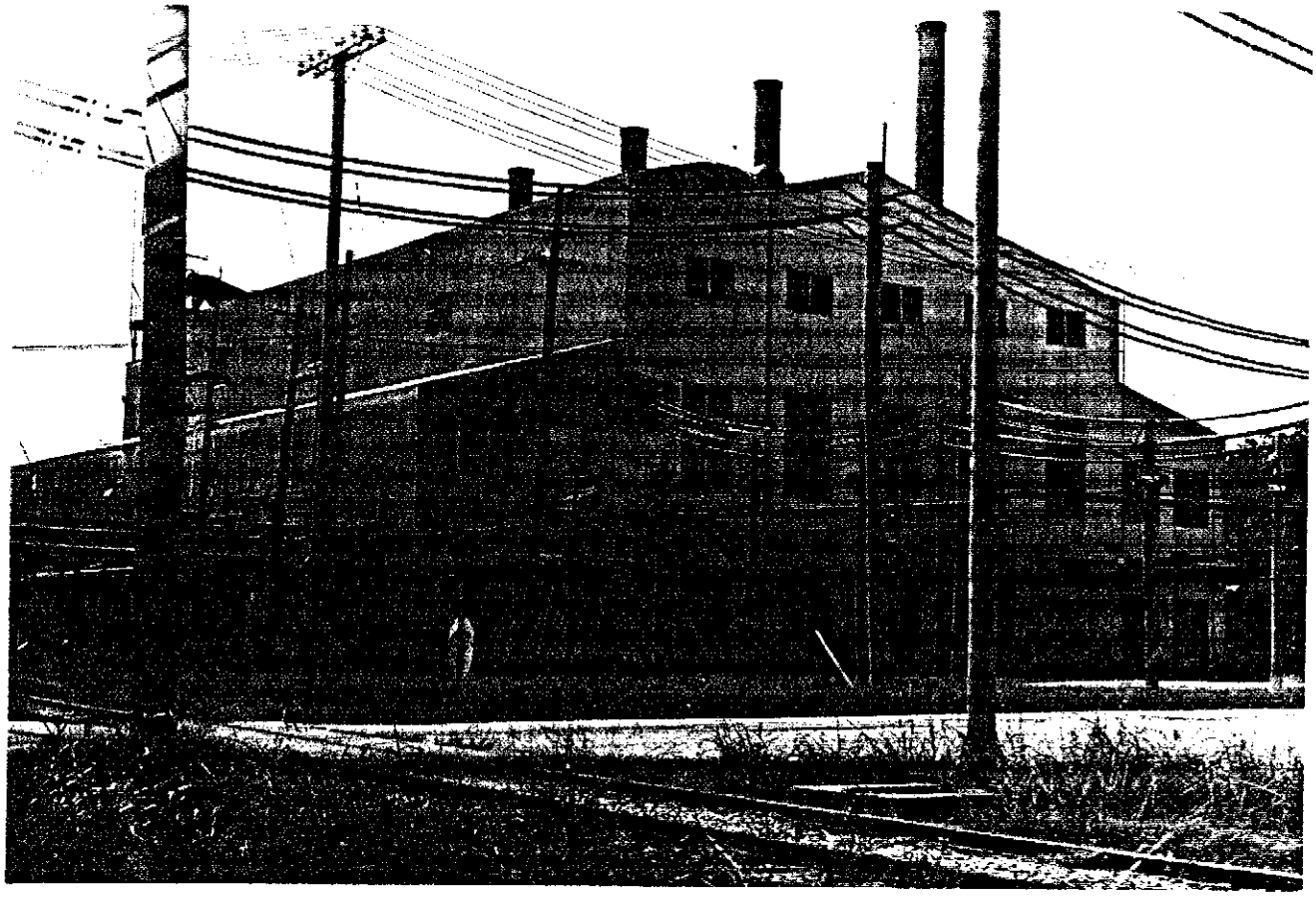

Figure 8: Power Plant (Building 401-2). (Source: Field inventory photograph, 1983, Peter Rathbun, MacDonald and Mack Partnership.)

The basic process for manufacturing TNT was relatively simple. Toluene, an organic chemical, was treated with nitric acid to produce crude trinitro toluene. The TNT was then purified in a washing process using soda ash, sellite (a compound made from soda ash and sulfur dioxide), and water. Finally the TNT then was dried, flaked, and readied for storage. Sulfuric acid was used as a dehydrating agent during the nitration process. VAAP obtained toluene and soda ash from outside vendors; it produced its own nitric and sulfuric acids, which deserve special mention.

The nitric acid facilities (Buildings 302-, 303-, and 312-1 through 3) were of standard industrial design, employing techniques developed by du Pont in the mid-1920s. Nitric acid was produced by vaporizing ammonia mixed with heated compressed air in the presence of a platinum catalyst to create nitrogen oxides. The nitrogen compounds were further oxidized with air and fed into an absorption tower, where they combined with water to form 60% nitric acid.[18] Like most industrial uses of nitric acid, the manufacture of TNT required a highly concentrated grade of the ingredient. To achieve this level of concentration, VAAP concentrated the 60% nitric acid by dehydrating it with strong sulfuric acid, which absorbed water from the nitric acid.[19]

The manufacture and concentration of sulfuric acid also employed standard industrial technology. In the manufacturing process sulfur was burned to produce sulfur dioxide, which was converted to sulfur trioxide as it passed over a platinum catalyst. The sulfur trioxide then was mixed with water to form sulfuric acid.[20] Dilute sulfuric acid from the manufacturing lines was concentrated either in Chemico drum concentrators (Buildings 308-3,

308-4), which removed water by blowing hot combustion gasses through the acid, or in Mantius concentrators (Buildings 308-1, 304-1, 304-2), which removed water through boiling in a vacuum.[21]

Although the chemistry of TNT production remained constant during World War II, the technology underwent significant change. In the early stages of the war, the acid mix was added to the toluene to initiate nitration. Later developments in Canada proved, however, that the toluene could be added to the acid in a "reverse nitration" process that was both safer and more productive. Each of these processes will be described briefly, along with the impact of the change on the buildings at VAAP.

As initially designed, the TNT production process began in the Mono House (Buildings 801-1 through 801-16) (Figure 7) where fortified nitric acid from the Bi-and-Tri-nitration house and a small amount of sulfuric acid were slowly added to toluene in an agitation tank. The toluene, reacting with the nitric acid, was transformed to mononitrotoluene or mono oil. Because of the danger of overheating during this exothermic reaction, the mixing tank was elevated to permit dumping of "hot" mixtures into a drowning tank below. The mono oil was piped to the Bi-and-Tri House (Buildings 802-1 through 802-16), while the spent acids were sent to the Acid-and-Fume Recovery House (Buildings 812-1 through 812-8) before returning to the acid areas for concentration. In the Bi-and-Tri House the mono oil was blended with successively stronger acid mixes. Here, too, the mixing tanks were elevated to permit drowning in case of overheating. The nitrotoluenes and spent acids were allowed to separate by gravity, the process oil moving on for purification and the acids going to the Forti-

fying House (Buildings 803-1 through 803-16) (Figure 9). This crude TNT mixture was purified in the Wash House (Buildings 806-1 through 806-16) (Figure 6) with a mixture of water, soda ash, and sellite. The purified TNT then was dried, flaked, and loaded into boxes for conveyance to the Nail House (now known as Case Houses, Buildings 808-1 through 808-8), where it was sampled and prepared for final shipment.[22]

The reverse nitration process used later at VAAP allowed the toluene to be slowly added to the acid. This process resulted in a more complete nitration in the mono- and bi- stages and reduced the fuming and other dangers of the tri-nitration.[23] To permit use of reverse nitration in the bi-stage, the Fortifying Houses were converted to Bi-Houses; drowning tanks were installed below these one-story buildings. Creation of the Bi-Houses freed both mixers in the Bi-and-Tri Houses for the tri-nitration operation, resulting in redesignation of the latter buildings as Tri-Houses.[24]

VAAP pioneered in the treatment of toxic wastes generated by its manufacturing processes. At most other TNT plants "redwater" and "yellow water," toxic wastes from the purification washes, simply flowed onto the ground. Such casual waste disposal was unacceptable at VAAP, however, because of the proximity of Lake Chickamauga, the primary source of water for the region. The Redwater Treatment Plant (Figure 10) consisted of an Evaporator (Building 816) and an Incinerator (Buildings 816-1, 816-2). The Evaporator concentrated the redwater to 35% solids. The remaining concentrate was sprayed into the Incinerator, a rotary traverse furnace, for burning; waste ash to fell into hoppers for disposal.[25]

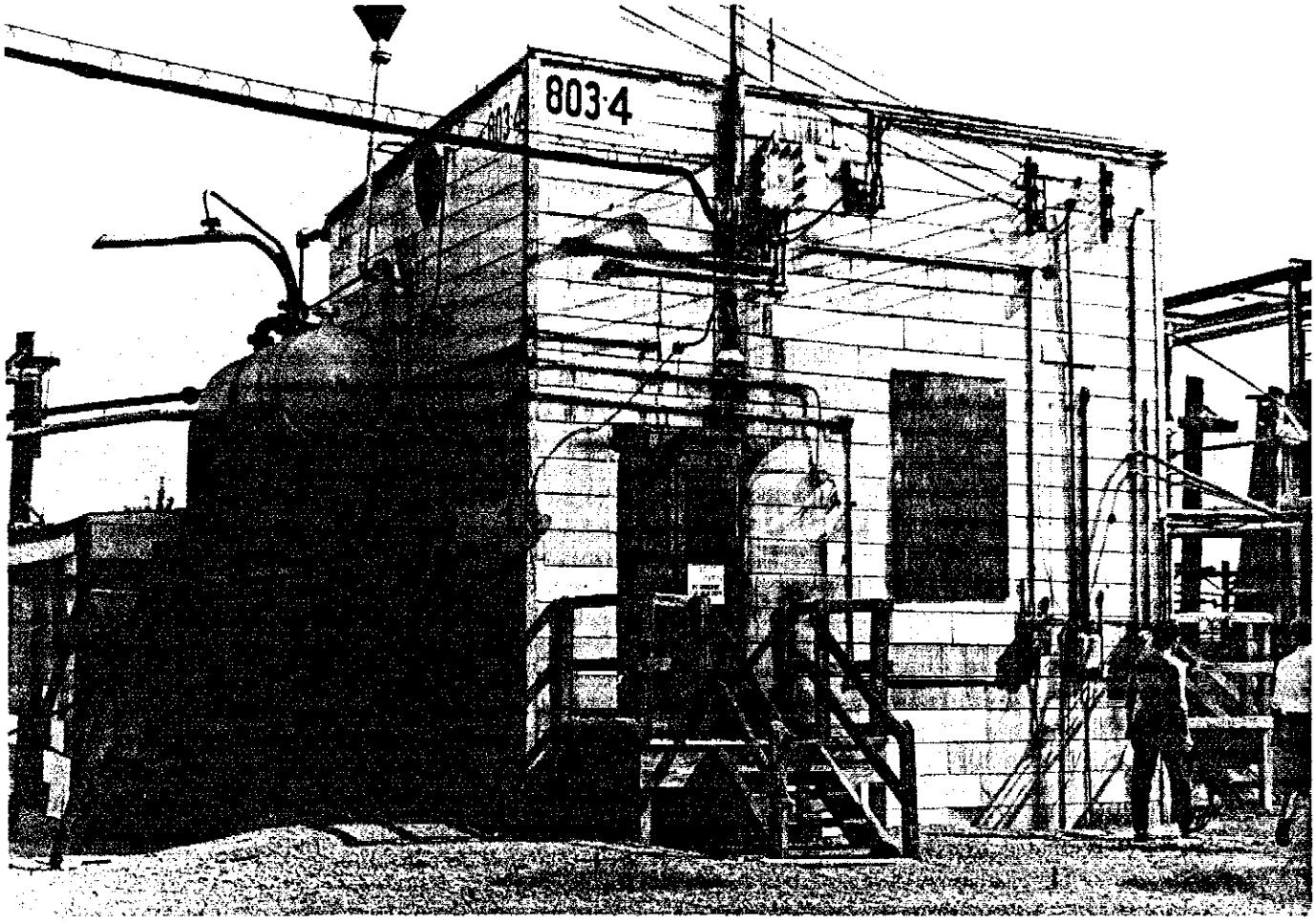

Figure 9: Bi-House (Building 803-4), formerly the Fortifying House. (Source: Field inventory photograph, 1983, Peter Rathbun, MacDonald and Mack Partnership.)

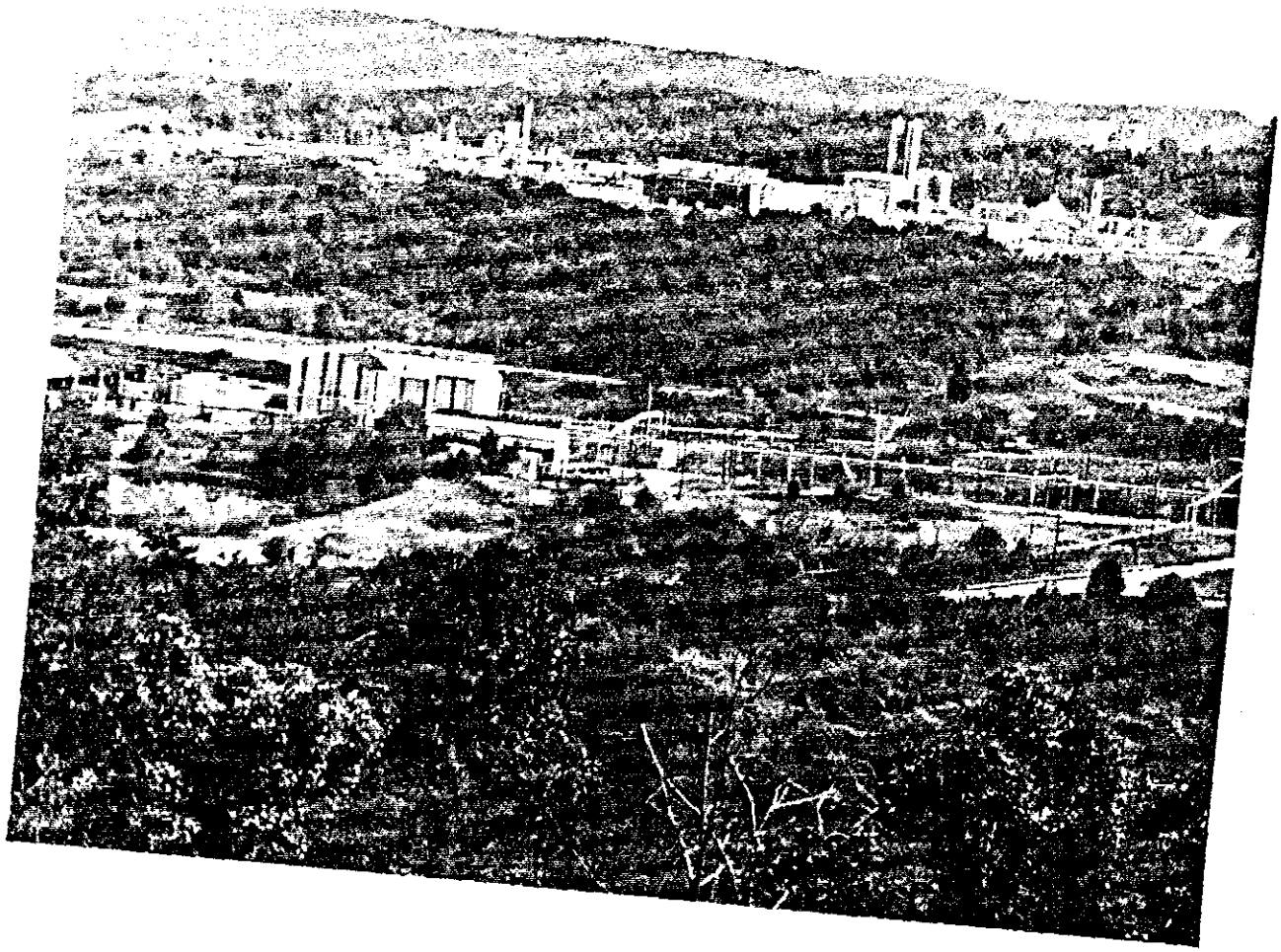

Figure 10: Redwater Treatment Plant (Buildings 816, 816-1, 816-2). Acid area in background. (Source: Field inventory photograph, 1983, Peter Rathbun, MacDonald and Mack Partnership.)

Manufacturing operations at VAAP stopped in August 1945, although the contract with Hercules continued in effect until January 1946, when the plant was turned over to the Ordnance Corps. Civil service personnel maintained the plant in standby condition for the next six years.

KOREAN WAR

VAAP was reactivated in June 1952 with Atlas Powder Company of Wilmington, Delaware, as the operating contractor. The plant had deteriorated, and extensive renovation work was necessary, especially at the Main Administration Building (Building 200-1), which had suffered a major fire. Six of the original TNT lines were demolished, while about 25 new support structures were constructed, including change houses and small administration buildings for the TNT lines.[26]

Production resumed in November 1953 and continued until March 1957. Only six, and sometimes fewer, lines were operated. Production techniques were unchanged from those used in the reverse nitration process instituted during World War II.[27] In 1957 the plant was placed in standby status, then was downgraded to "protective surveillance."[28]

VIETNAM WAR TO THE PRESENT

In October 1965 VAAP again was reactivated. A modernization program and the construction of 117 new buildings during the next ten years had a major impact on both the plant layout and the manufacturing processes at VAAP.[29]

Construction

Rehabilitation of ten TNT lines began immediately upon reactivation, and the first line began production in March 1966. A new Acid Area (Buildings 100 - 107, 115) (Figure 11) was constructed in 1970-1972. The three original acid areas, except for a few minor buildings, were demolished; four TNT lines also were demolished. Six new "continuous process" TNT lines (Buildings 800-A1 through 800-F6, 810-A and 810-D, and 811-A and 811-D) (Figure 12) were constructed. Additional construction during this period included a hospital (now used as the main administration building), storehouses, and shops.[30]

Technology

The production of TNT by a continuous process, rather than by the batch method, represented a major technological advancement. While the daily output of each line is approximately equal to the output of each batch line, the continuous production process offered advantages in the areas of cleanliness, reduced pollution, labor savings, and greater control over the operations. The continuous process lines at VAAP employed techniques developed and refined at other locations; VAAP was unique in utilizing a direct computer process control system. In the continuous production process, the nitration takes place in a series of small interconnected tanks. Toluene is continuously fed into the first tank where it is agitated with countercurrent spent acid to cause partial nitration. As more raw materials are added, the partially nitrated materials are agitated into the next tank, where additional acid is fed into the mix to continue the nitration

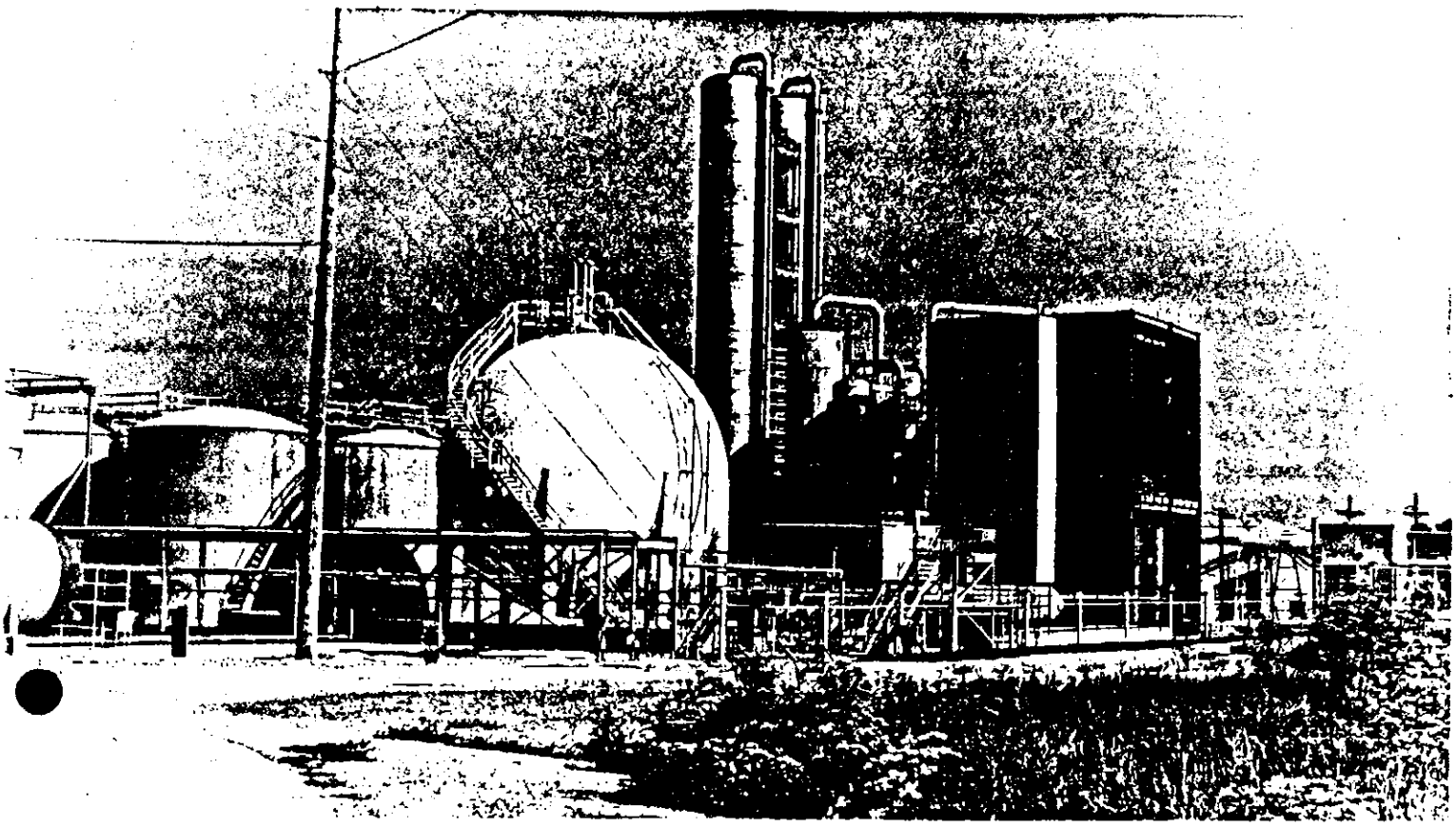

Figure 11: Direct Strong Nitric Acid Production facility (Building 103). Other facilities in the new acid area include an AOP nitric acid facility, sulfuric acid regeneration facility, and oleum production unit. (Source: Field inventory photograph, 1983, Peter Rathbun, MacDonald and Mack Partnership.)

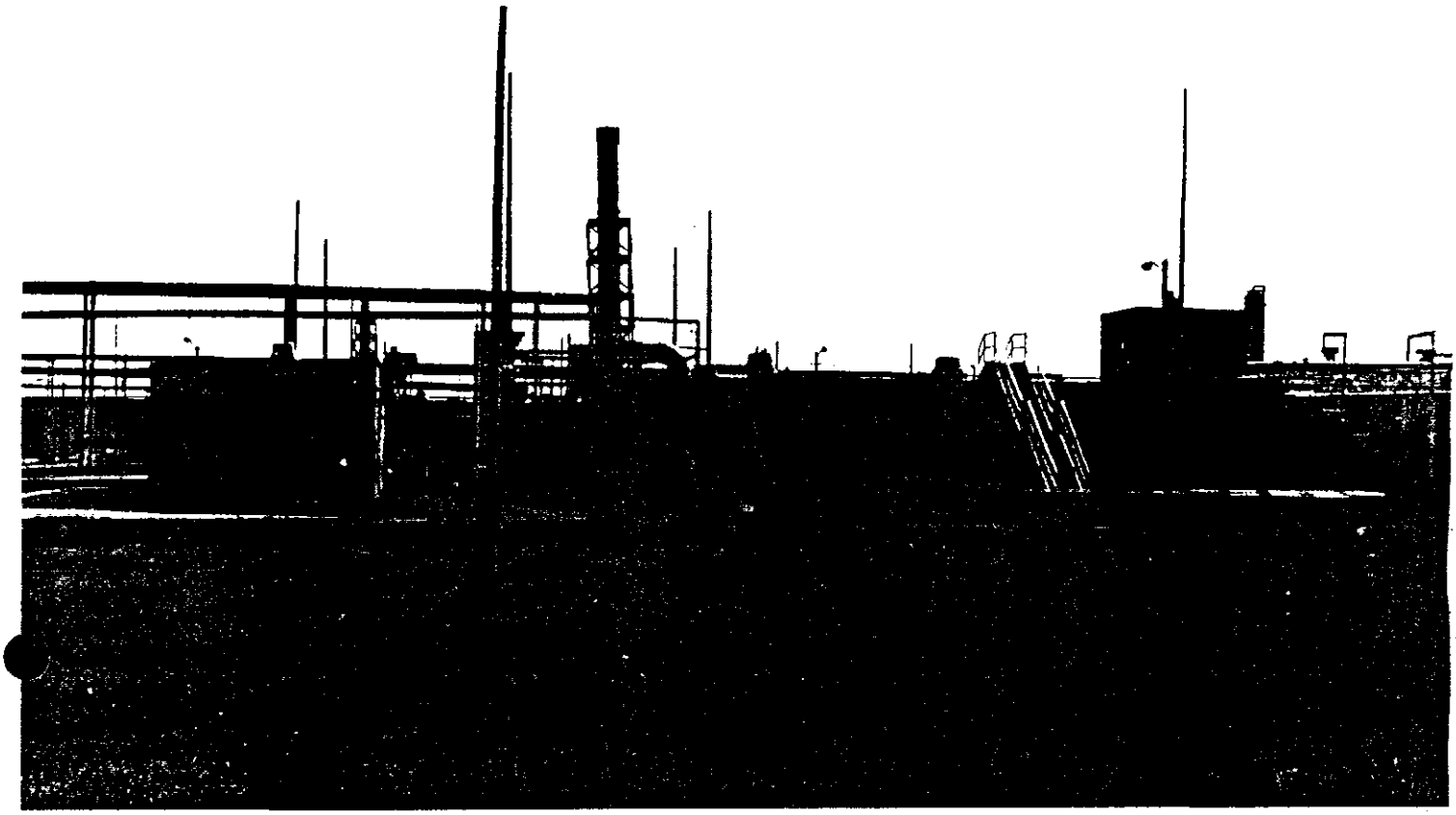

Figure 12: TNT Nitrating and Purifying Building (Building 800-C1). The production building is within the berm. The building to the left is a utility building (Building 800-C2). (Source: Field inventory photograph, 1983, Peter Rathbun, MacDonald and Mack Partnership.)

process. Reacting materials continue to move through the system until nitration is complete. The unpurified TNT is washed and then piped to a finishing house for drying, flaking, and packing.[31]

NOTES

1. Volunteer Army Ammunition Plant, "DARCOM Installation and Activity Brochure," pp. 1-3 unpublished document, 1980, in Administrative Office files, VAAP.

2. The Real Property Inventory Printout of March 31, 1982, indicates that there are 236 buildings from World War II, 70 from the Korean War, and 116 from the Vietnam War; field examination and construction records indicate that 45 of the buildings attributed to the Korean War period were, in fact, built in 1942-1943 and had only small sheds added in 1952. U.S. Army Materiel Development and Readiness Command (DARCOM), "Volunteer AAP Real Preoperty Inventory Printout," computer printout, March 31, 1982; Area Engineer, Volunteer Ordnance Works, "Completion Report of . . . Construction of T.N.T. Plant and Facilities at Volunteer Ordnance Works . . .," unpublished report, July 1, 1943, in Administrative Office files, VAAP; U.S. Army Corps of Engineers, Office of the District Engineer, Savannah, Ga., "Industrial Facilities Inventory, Volunteer Ordnance Works," unpublished report, 1943, on file at AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Ill.); and idem, "Industrial Facilities Inventory, Volunteer Ordnance Works, Supplement #1," unpublished report, 1945, on file at AMCCOM Historcal Office.

3. Building use was determined by government category code; some support structures, such as change houses in the TNT area, are considered production facilities. "Completion Report;" "Real Property Inventory;" and Volunteer Army Ammunition Plant, "Facility List," pp. 1-8, unpublished report, February 15, 1983, in contractor files, VAAP.

4. Harry C. Thomson and Lida Mayo, The Ordnance Department: Procurement and Supply, (Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1960), pp. 104-106.

5. William Voight, Jr., "The Ordnance Organization in World War II," pp. 309-310, unpublished report, 1945, on microfiche at AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Illinois; A. Robert Ginsburgh, "Chemical Munitions Plants: A Lesson in Economic Geography," Chemical & Metallurgical Engineering, 47 (November 1940), 768-769, 784; and Thomson and Mayo, p. 108.

6. A number of perimeter tracts of land have been transferred from government ownership, including a sizeable section containing a Civil War historic site that was given to Hamilton County, Tenn., for a

recreation area, land sold to two churches, and a parcel donated to the Army Reserve. ICI Americas, Inc., "Executive Order 11508 Installation Survey," unpublished map, February 19, 1982, in contractor files, VAAP); idem, "Volunteer AAP Installation Plot Plan, " unpublished map, February 10, 1981, in contractor files, VAAP; interview with James Fry, Commanding Officer's Representative, VAAP, September 26, 1983; and interviews with Richard Twitchell, Supervisor for Engineering, ICI Americas, September 26 and 27, 1983.

7. The last of the buildings were sold and removed by June 1945. Hercules Powder Co., "Facilities Historical Record, Volunteer Ordnance Works," unpublished report for the quarter 1 April - 30 June 1945, in Administrative Office files, VAAP.

8. In 1941 VAAP officially was designated Volunteer Ordnance Works. The name was changed to Volunteer Army Ammunition Plant (VAAP) in 1963. For the sake of clarity and brevity, the plant's current name is used throughout this report.

9. Lenore Fine and Jesse A. Remington, The Corps of Engineers: Construction in the United States, (Wasington, D.C.: Office of the Chief of Military History, United States Army, 1972), p. 316.

10. "Completion Report," p. 132.

11. "Completion Report," pp. 1, and 132; "Facilities Inventory," pp. 1-4 through 1-6.

12. "Completion Report;" "Facilities Inventory."

13. Hercules Powder Co., "VOW: Magazine - Building 901," two unpublished construction drawings dated October 1940 and October 1941, on file at the AMCCOM Historical Office, Rock Island Arsenal; C. H. Cotter, "Naval Ammunition Depot Near Hawthorne, Nev., Built to Serve the Pacific Coast," Engineering News-Record, 105 (November 20, 1930), 803-805; Paul Nissen, "Igloos of Concrete," Pacific Builder and Engineer, 47 (September 1941), 40-44; Fine and Remington, pp. 333-334.

14. "Completion Report," pp. 1, 132; "Facilities Inventory," pp. 1-4 through 1-6.

15. George D. Rogers, "Military Explosives," National Safety News, (July 1941), 22-23, 77-80; John R. Mardick, "Safety's Triangle," Safety Engineering, (April 16, 1942), 13-14; and Thomson and Mayo, pp. 130-133.

16. Fine and Remington, pp. 327-341; "Completion Report," pp. 135-137. The Completion Report gives detailed descriptions of the construction and materials of each building type and describes the important processing machinery in them.

17. "Completion Report," p. 135.

18. Guy B. Taylor and others, "Manufacture of Nitric Acid by the Oxidation of Ammonia," Industrial and Engineering Chemistry, 23 (August 1, 1931) 860-865.

19. "IAAP [Indiana Army Ammunition Plant] Chemical Division Manual," Section II (Acid), p. 4, unpublished document, n.d., in ICI Americas Arcives, Indiana Army Ammunition Plant, Charlestown, Indiana.

20. Thomson and Mayo, pp. 134-135; R. Norris Shreve, The Chemical Process Industries, (New York: McGraw-Hill, 1956), pp. 383-392; "Completion Report," pp. 19-20.

21. Shreve, pp. 277-383; "Completion Report," pp. 18-23.

22. Richard Twitchell, "Production of Our End Product - TNT," unpublished diagram, n.d., in Uniroyal files, Joliet Army Ammunition Plant, Joliet, Illinois; Jules Bebie, "Making Explosives for World War II," Chemical & Metallurgucal Engineering, 48 (October 1941) 6-8; Hercules Powder Co., "Historical Record: Volunteer Ordnance Works," unpublished report, 1944, in local history collection, Chattanooga Public Library; "Making T.N.T.: Electrical Aspects of a Large Factory," Electrical Review, 136 (February 2, 1945), 153-157; Shreve, pp. 458-459; Rogers, pp. 22-23, 77-79.

23. Philip J. Raifsnider, "New Techniques Improve TNT Manufacture," Chemical Industries, 57 (December 1945), 1054-1056; Thomson and Mayo, pp. 134-135.

24. "Facilities Inventory Supplement," pp. 1-7 and 1-8.

25. C. C. Ruchhoft, M. LeBosquet, Jr., and William G. Meckler, "TNT Wastes from Shell-Loading Plants," Industrial and Engineering Chemistry, 37 (October 1945), 937-943; Russell S. Smith and W. W. Walker, "Surveys of Liquid Wastes from Munitions Manufacturing," Public Health Reports, 58 (September 10, 1943), 1365-1373; Rogers, pp. 77-79; R.J. Hammond, "Profile on Munitions, 1950-1977," p. 98, unpublished report, n.d., on microfiche at AMCCOM Historical Office, Rock Island Arsenal; "Completion Report," p. 22.

26. "Activity Brochure," p. 1; Chattanooga Times, December 10, 1962.

27. "Activity Brochure," p. 1.

28. Chattanooga Times, May 5, 1962.

29. Atlas Powder Company has had several name changes and now is called ICI Americas, Inc. Twitchell interview; "Real Property Inventory"; "Activity Brochure," p. 2.

30. Twitchell interview; "Real Property Inventory"; "Activity Brochure."

31. "Real Property Inventory"; Twitchell interview.

Chapter 3

PRESERVATION RECOMMENDATIONS

BACKGROUND

Army Regulation 420-40 requires that an historic preservation plan be developed as an integral part of each installation's planning and long-range maintenance and development scheduling.[1] The purpose of such a program is to:

- Preserve historic properties to reflect the Army's role in history and its continuing concern for the protection of the nation's heritage.
- Implement historic preservation projects as an integral part of the installation's maintenance and construction programs.
- Find adaptive uses for historic properties in order to maintain them as actively used facilities on the installation.
- Eliminate damage or destruction due to improper maintenance, repair, or use that may alter or destroy the significant elements of any property.
- Enhance the most historically significant areas of the installation through appropriate landscaping and conservation.

To meet these overall preservation objectives, the general preservation recommendations set forth below have been developed:

Category I Historic Properties

All Category I historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for

nomination regardless of age. The following general preservation recommendations apply to these properties:

a) Each Category I historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category I historic properties should not be altered or demolished. All work on such properties shall be performed in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation (ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).

b) An individual preservation plan should be developed and put into effect for each Category I historic property. This plan should delineate the appropriate restoration or preservation program to be carried out for the property. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulation. Until the historic preservation plan is put into effect, Category I historic properties should be maintained in accordance with the recommended approaches of the Secretary of Interior's Standards for Rehabilitation and

Revised Guidelines for Rehabilitating Historic Buildings[2] and in consultation with the State Historic Preservation Officer.

c) Each Category I historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.[3] When no adequate architectural drawings exist for a Category I historic property, it should be documented in accordance with Documentation Level I of these standards. In cases where standard measured drawings are unable to record significant features of a property or technological process, interpretive drawings also should be prepared.

Category II Historic Properties

All Category II historic properties not currently listed on or nominated to the National Register of Historic Places are assumed to be eligible for nomination regardless of age. The following general preservation recommendations apply to these properties:

a) Each Category II historic property should be treated as if it were on the National Register, whether listed or not. Properties not currently listed should be nominated. Category II historic properties should not be altered or demolished. All work on such properties shall be performed

in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation (ACHP) as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800).

b) An individual preservation plan should be developed and put into effect for each Category II historic property. This plan should delineate the appropriate preservation or rehabilitation program to be carried out for the property or for those parts of the property which contribute to its historical, architectural, or technological importance. It should include a maintenance and repair schedule and estimated initial and annual costs. The preservation plan should be approved by the State Historic Preservation Officer and the Advisory Council in accordance with the above-referenced ACHP regulations. Until the historic preservation plan is put into effect, Category II historic properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings[4] and in consultation with the State Historic Preservation Officer.

c) Each Category II historic property should be documented in accordance with Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) Documentation Level

II, and the documentation submitted for inclusion in the HABS/HAER collections in the Library of Congress.[5]

Category III Historic Properties

The following preservation recommendations apply to Category III historic properties:

a) Category III historic properties listed on or eligible for nomination to the National Register as part of a district or thematic group should be treated in accordance with Sections 106 and 110(f) of the National Historic Preservation Act as amended in 1980, and the regulations of the Advisory Council for Historic Preservation as outlined in the "Protection of Historic and Cultural Properties" (36 CFR 800). Such properties should not be demolished and their facades, or those parts of the property that contribute to the historical landscape, should be protected from major modifications. Preservation plans should be developed for groupings of Category III historic properties within a district or thematic group. The scope of these plans should be limited to those parts of each property that contribute to the district or group's importance. Until such plans are put into effect, these properties should be maintained in accordance with the recommended approaches in the Secretary of the Interior's Standards for Rehabilitation and Revised

Guidelines for Rehabilitating Historic Buildings[6] and in consultation with the State Historic Preservation Officer.

b) Category III historic properties not listed on or eligible for nomination to the National Register as part of a district or thematic group should receive routine maintenance. Such properties should not be demolished, and their facades, or those parts of the property that contribute to the historical landscape, should be protected from modification. If the properties are unoccupied, they should, as a minimum, be maintained in stable condition and prevented from deteriorating.

HABS/HAER Documentation Level IV has been completed for all Category III historic properties, and no additional documentation is required as long as they are not endangered. Category III historic properties that are endangered for operational or other reasons should be documented in accordance with HABS/HAER Documentation Level III, and submitted for inclusion in the HABS/HAER collections in the Library of Congress.[7] Similar structures need only be documented once.

CATEGORY I HISTORIC PROPERTIES

There are no Category I historic properties at the Volunteer AAP.

CATEGORY II HISTORIC PROPERTIES

There are no Category II historic properties at the Volunteer AAP.

CATEGORY III HISTORIC PROPERTIES

Redwater Treatment Plant (Buildings 816, 816-1, 816-2)

. Background and significance. The purification and washing of TNT produced toxic wastes known as "redwater" and "yellow water." Prior to the Koren War few TNT plants made provision for disposal of these wastes other than letting them run onto the ground. At Volunteer Army Ammunition Plant, however, proximity to a major water source mandated safe disposal of toxic by-products. A Redwater Treatment Plant (which treated yellow water, as well) was built, therefore, along with production and support buildings in 1941-1942. The Redwater Treatment Plant consisted of an Evaporator Building (Building 816) and Incinerator Buildings (Buildings 816-1, 816-2). The exterior cladding of the Evaporator Building has been replaced, but the equipment and structural systems are intact. The Redwater Treament Plant at VAAP is a Category III Historic Property because it is a good example of an early pollution abatement effort at a TNT production facility.

. Condition and potential adverse impacts. The Redwater Treatment Plant at VAAP is in good condition and undergoes routine maintenance as part of the standby activities at the plant. There are currently no plans that would have an adverse impact on the property.

. Preservation options. The Redwater Treatment Plant at VAAP should be maintained in accordance with the preservation recommendations for Category III Historic Properties described above.

NOTES

1. Army Regulation 420-40, Historic Preservation (Headquarters, U.S. Army: Washington, D.C., 15 April 1984).

2. National Park Service, Secretary of Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings, 1983 (Washington, D.C.: Preservation Assistance Division, National Park Service, 1983).

3. National Park Service, "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines," Federal Register, Part IV, 28 September 1983, pp. 44730-44734.

4. National Park Service, Secretary of the Interior's Standards.

5. National Park Service, "Archeology and Historic Preservation."

6. National Park Service, Secretary of the Interior's Standards.

7. National Park Service, "Archeology and Historic Preservation."

BIBLIOGRAPHY

Applied Science and Technology Index. 1958-1980.

Area Engineer, Volunteer Ordnance Works. "Completion Report of . . . Construction of T.N.T. Plant and Facilities at Volunteer Ordnance Works . . . ." Unpublished report, July 1, 1943. Administration Building, VAAP. Contains detailed descriptions of the buildings and machinery at the plant, with photos and charts.

ARRCOM. Catalog of Common Sources, Fiscal Year 1983. 2 vols. no pl.: AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Illinois, n.d. Catalog of documents on microfiche.

Bebie, Jules. "Making Explosives for World War II.: Chemical & Metallurgical Engineering, 48 (October 1941), 6-8. Brief overview of explosives preparation early in the war.

Berl, Walter E. "Explosives." Chemical & Metallurgical Engineering, 52 (May 1945), 202, 204, 206. Discusses the use of continuous processing for the manufacture of explosives.

Chattanooga Times, December 10, 1952. News article on the reactivation of VAAP.

Chattanooga Times, May 5, 1962. News article about the status of VAAP.

Cotter, C. H. "Naval Ammunition Depot Near Hawthorne, Nev., Built to Serve the Pacific Coast." Engineering News-Record, 105 November 20, 1930), 803-805. Discusses the design and spacing of magazines.

Engineering Index. 1938-1983.

Fine, Lenore, and Remington, Jesse A. The Corps of Engineers; Construction in the United States. Washington, D.C.: Office of the Chief of Military History, United States Army, 1972. Good overview of the conditions affecting construction of ordnance works during the war.

Ginsburgh, A. Robert. "Chemical Munitions Plants: A Lesson in Economic Geography." Chemical & Metallurgical Engineering, 47 (November 1940), 768-769, 784. Provides the rationale for the location of ordnance plants.

Hammond, R. J. "Profile on Munitions, 1950-1977." Unpublished report prepared for the Ordnance Department, n.d. On microfiche, AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Ill. Brief overview of some of the problems faced by VAAP in this period.

Hercules Powder Co. "Facilities Historical Record, Volunteer Ordnance Works." Unpublished report for the quarter April 1 - June 30, 1945. Administration Building, VAAP. Covers operations and construction during this period.

_____. "Historical Record: Volunteer Ordnance Works." Unpublished report, 1944. Local history collection, Chattanooga Public Library, Chattanooga, Tenn. Presents an outline of the constructin and operation of VAAP.

_____. "VOW: Magazine - Building 901." Two unpublished construction drawings dated October 1940 and October 1941. AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Ill.

_____. "VOW: TNT Lines - Building 802 -- 1-12." Two unpublished construction drawings dated August 1941. AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Ill.

Higham, Robin ed. A Guide to the Sources of United States Military History. Hamden, Conn.: Archon Books 1975.

Historic American Buildings Survey / Historic American Engineering Record. Guidelines for Inventories of Historic Buildings and Engineering and Industrial Structures. Unpublished draft, 1982.

Hoy, Suellen M., and Robinson, Michael C., eds. Public Works History in the United States. Nashville: American Association for State and Local History, 1982.

ICI Americas, Inc. "Executive Order 11508 Installation Survey. Unpublished map, February 19, 1982, ICI Americas files, VAAP.

_____. "Volunteer AAP Installation Plot Plan." Unpublished map, February 10, 1981, ICI Americas files, VAAP.

Industrial Arts Index. 1938-1957.

Jessup, John E. and Robert W. Coakley. A Guide to the Study and Use of Military History. Washington: U.S. Government Printing Office, 1979.

"Making T.N.T.: Electrical Aspects of a Large Factory." Electrical Review, 136 (February 2, 1945), 153-157. Although concerned primarily with electrical machinery, this covers the process equipment, as well.

Mardick, John R. "Safety's Triangle." Safety Engineering, (April 16, 1942), 13-14. Addresses the issue of safety at ordnance plants.

National Park Service. "Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines." Federal Register, Part IV (28 September 1983), 44730-44734.

_____. How to Complete National Register Forms. Washington, D.C.: U.S. Government Printing Office, January, 1977.

_____. Secretary of the Interior's Standards for Rehabilitation and Revised Guidelines for Rehabilitating Historic Buildings, 1983. Washington, D.C.: Preservation Assistance Division, National Park Service, 1983.

Nissen, Paul. "Igloos of Concrete." Pacific Builder and Engineer, 47 (September 1941), 40-44. Covers construction of explosives storage magazines.

"Production of Our End Product - TNT." Unpublished diagram, n.d., Uniroyal files, Joliet Army Ammunition Plant, Joliet, Ill. Gives a clear, simplified diagram of TNT production.

Raifsnider, Philip J. "New Techniques Improve TNT Manufacture." Chemical Industries, 57 (December 1945), 1054-1056. Explains the impact of reverse nitration and other improvements in TNT production.

Rogers, George D. "Military Explosives." National Safety News, (July 1941), 22-23, 77-80. Good examination of both construction and operating safety issues and methods.

Ruchhoft, C. C.; LeBosquet, M., Jr.; and Meckler, William G. "TNT Wastes from Shell-Loading Plants." Industrial and Engineering Chemistry, 37 (October 1945), 937-943. Discusses the disposal of redwater waste.

Shreve, R. Norris. The Chemical Process Industries. New York: McGraw-Hill, 1956. Detailed explanation of the production of sulfuric and nitric acids.

Slachman, P. G. "Procurement of Raw Materials for High Explosives." Chemical & Metallurgical Engineering, 52 (October 1945), 113-114. Brief examination of raw material procurement difficulties.

Smith, Russell S., and Walker, W. W. "Surveys of Liquid Wastes from Munitions Manufacturing." Public Health Reports, 58 (September 10, 1943) 1365-1373. Report of investigations on redwater.

Thomson, Harry C., and Mayo, Lida. The Ordnance Department: Procurement and Supply. Washington, D.C.: Office of the Chief of Military History, Department of the Army, 1960. Good overview of the construction of ordnance plants from the Ordnance Department's point of view.

United States Army Armament Materiel Readiness Command. Catalog of Common Sources, Fiscal Year 1983. No. pl.: Historical Office, AMCCOM, Rock Island Arsenal, Rock Island, Ill.

U.S. Army Corps of Engineers, Office of the District Engieer, Savannah, Ga. "Industrial Facilities Inventory, Volunteer Ordnance Works." Unpublished report, 1943. On file at AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Ill. Describes the buildings at VAAP in 1943.

_____. "Industrial Facilities Inventory, Volunteer Ordnance Works, Supplement #1." Unpublished report, 1945. On file at AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Ill. Relates additions and changes to initial report.

U.S. Army Materiel Development and Readiness Command. "Volunteer AAP Real Property Inventory Printout." Computer printout, March 31, 1982.

U.S. Army Munitions Command. Modernization Enineering Report for U.S. Army Ammunition Plants. U.S. Army Munitions Command, Dover, New Jersey: August 1970. Describes capabilities and status of AAPs as of 1970.

Voight, William, Jr. "The Ordnance Organization in World War II." Unpublished report prepared for the Ordnance Department, 1945. On microfiche, AMCCOM Historical Office, Rock Island Arsenal, Rock Island, Ill. Brief review of VAAP at the end of the war.

Volunteer Army Ammunition Plant. DARCOM Installation and Activity Brochure. Unpublished document, 1980. Administration Building, VAAP. Contains good, brief plant history.

_____. "Facility List." Unpublished report, February 15, 1983. ICI Americas, Inc., VAAP.